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CAR DRIVER ATTITUDE MONITORING SYSTEM USING FUZZY LOGIC WITH THE INTERNET OF THINGS

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Abstract. *The Internet of Things (IoT) can become reality because mobile Internet now has large coverage and bandwidth, which makes IoT work in the real-time environment. In IoT, the data from sources/devices are sent to the cloud using the Internet so the data can be analyzed for taking actions. IoT makes devices increasingly smart. This research uses a device called On Board Diagnostics-II (OBD-II), which takes data from a car and sends it to a server on IBM Bluemix using mobile Internet. The data is then processed by an application at IBM Bluemix. By using two kinds of data from a car, i.e., speed and rpm, the attitude of the driver can be monitored by applying fuzzy logic. The attitude of the driver is judged by the percentages of good and bad driving behavior. This system has been tested on the road in Bandung, Indonesia.*
Keywords: Driver attitude, Car driving, Internet of Things, Fuzzy logic

1. **Introduction.** Social psychology addresses the elements of the attitude of individuals or groups. Attitude can be defined as the way individuals respond to a stimulus in the social environment. It refers to the tendency to approach or avoid various social circumstances, institutions, persons, situations, ideas, concepts, etc.

The attitude when driving is important for the safety of the driver and his vehicle. For example, exceeding the speed limit could lead to accidents that can harm the driver or other people. Doing so continuously could also damage the car's engine which will require maintenance sooner than should be necessary. This paper discusses how to determine the attitude of a car driver and classify the driver's behavior as good or bad based on the fuzzy logic methods of Tsukamoto and IBM Bluemix.

2. **System Design.** The system for determining driver attitude comprises three stages. In the first stage, data from the car are collected using On Board Diagnostics-II (OBD-II) and forwarded to a smartphone using Bluetooth. The data are uploaded to the IBM Bluemix server from the smartphone using mobile Internet [1-3]. Finally, the data is analyzed on the server and the results are visible to the authorized users. Figure 1 shows the block diagram of the overall system.

2.1. **IBM Bluemix.** IBM Bluemix was designed to be integrated with IBM software, resulting in a very diverse service Application Programming Interface (API). Some services are even in the enterprise category. In general, the Bluemix platform can run multiple Cloud Foundry applications such as Liberty for Java, SDK for Node.js, ASP.NET Core, Runtime for Swift, XPages, Go, PHP, Python, Ruby, and Tomcat. The monitoring system in the car uses the Cloud Foundry application PHP.

In addition, IBM Bluemix has a service for data storage and analytics. This service of data and analytics provides many platforms such as Cloudant NoSQL DB, ClearDB

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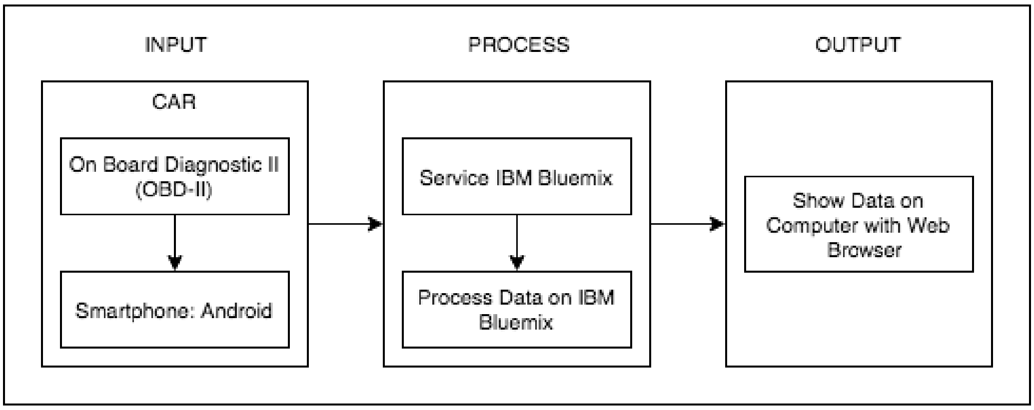

FIGURE 1. Block diagram of the overall system

MySQL Database, dashDB, and Composer for etcd. IBM Bluemix has currently prepared over thirty types of platform services in data and analytics. This study uses ClearDB MySQL Database.

2.2. **Tsukamoto fuzzy logic.** The first step of fuzzy methods is to establish the input and output variables. The system described in this paper determines the attitude of the driver using the input parameters of the car's speed and rpm. The speed parameter is based on Indonesian road rules and regulations and has three categories, i.e., low, average and high speed. Low speed is below 30km/h, average speed is between 30-50km/h, and high speed is above 50km/h. The rpm also has the three categories of low, average and high rpm. Low rpm is below 1000 rpm, average rpm is between 1000-2000 rpm and high rpm is above 2000 rpm. The output value of the driver's attitude is between 0 and 100 based on the criterion-referenced evaluation method [4-8]. It has three categories: the driver attitude is good if the output value is over 80, bad if the value is below 30, and average if the output value is between 30 and 80.

Based on the above categories the following nine fuzzy logic rules were developed.

1) IF the speed is low AND the rpm is low THEN the driver attitude is good.
2) IF the speed is low AND the rpm is average THEN the driver attitude is good.
3) IF the speed is low AND the rpm is high THEN the driver attitude is bad.
4) IF the speed is average AND the rpm is low THEN the driver attitude is good.
5) IF the speed is average AND the rpm is average THEN the driver attitude is good.
6) IF the speed is average AND the rpm is high THEN the driver attitude is bad.
7) IF the speed is high AND the rpm is low THEN the driver attitude is good.
8) IF the speed is high AND the rpm is average THEN the driver attitude is bad.
9) IF the speed is high AND the rpm is high THEN the driver attitude is bad.

In addition to the process of determining the fuzzy rules, there are also implications for the process of determining the value of the fuzzy output. Here, the value of α is the antecedent part that overlaps the input data for every rule, whereas the value of z determines the attitude of the driver [9-11]; the specified value is between 0 and 100. Figures 2-10 show the graphs of the fuzzy implications for rules 1 to 9. Based on the fuzzy set membership functions [12], Equations (1)-(18) are obtained to determine the values α and z for every rule.

$$\alpha 1 = \frac{z1 - z_{\min}}{z_{\max} - z_{\min}} \quad (1)$$

$$z1 = \alpha 1(z_{\max} - z_{\min}) + z_{\max} \quad (2)$$

$$\alpha 2 = \frac{z2 - z_{\min}}{z_{\max} - z_{\min}} \quad (3)$$

$$z2 = \alpha 2(z_{\max} - z_{\min}) + z_{\max} \quad (4)$$

$$\alpha 3 = \frac{z_{\min} - z3}{z_{\max} - z_{\min}} \tag{5}$$

$$z3 = \alpha 3(z_{\max} - z_{\min}) - z_{\max} \tag{6}$$

$$\alpha 4 = \frac{z4 - z_{\min}}{z_{\max} - z_{\min}} \tag{7}$$

$$z4 = \alpha 4(z_{\max} - z_{\min}) + z_{\max} \tag{8}$$

$$\alpha 5 = \frac{z5 - z_{\min}}{z_{\max} - z_{\min}} \tag{9}$$

$$z5 = \alpha 5(z_{\max} - z_{\min}) + z_{\max} \tag{10}$$

$$\alpha 6 = \frac{z_{\max} - z6}{z_{\max} - z_{\min}} \tag{11}$$

$$z6 = \alpha 6(z_{\max} - z_{\min}) - z_{\max} \tag{12}$$

$$\alpha 7 = \frac{z7 - z_{\min}}{z_{\max} - z_{\min}} \tag{13}$$

$$z7 = \alpha 7(z_{\max} - z_{\min}) + z_{\max} \tag{14}$$

$$\alpha 8 = \frac{z_{\max} - z8}{z_{\max} - z_{\min}} \tag{15}$$

$$z8 = \alpha 8(z_{\max} - z_{\min}) - z_{\max} \tag{16}$$

$$\alpha 9 = \frac{z_{\max} - z9}{z_{\max} - z_{\min}} \tag{17}$$

$$z9 = \alpha 9(z_{\max} - z_{\min}) - z_{\max} \tag{18}$$

Figure 11 shows the relation between the input values (speed and rpm) and the output value (attitude of the driver). The functions are formed using predetermined rules and

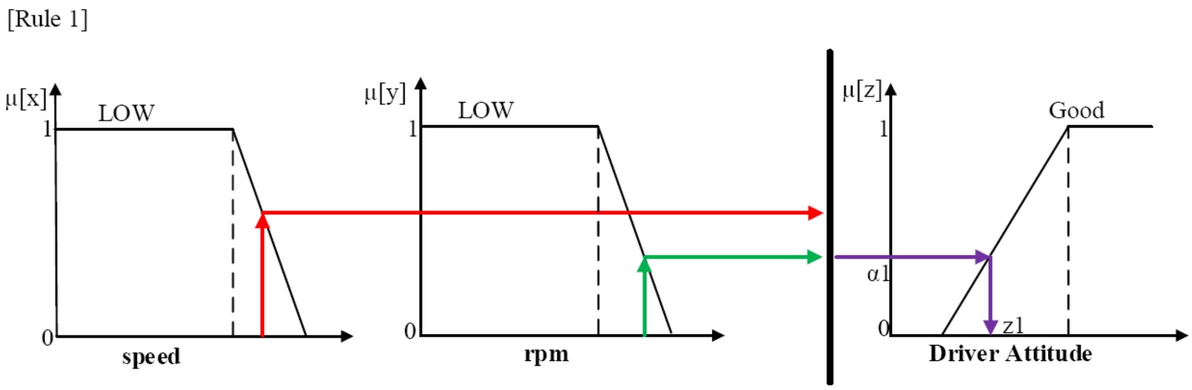

FIGURE 2. Implication of rule 1

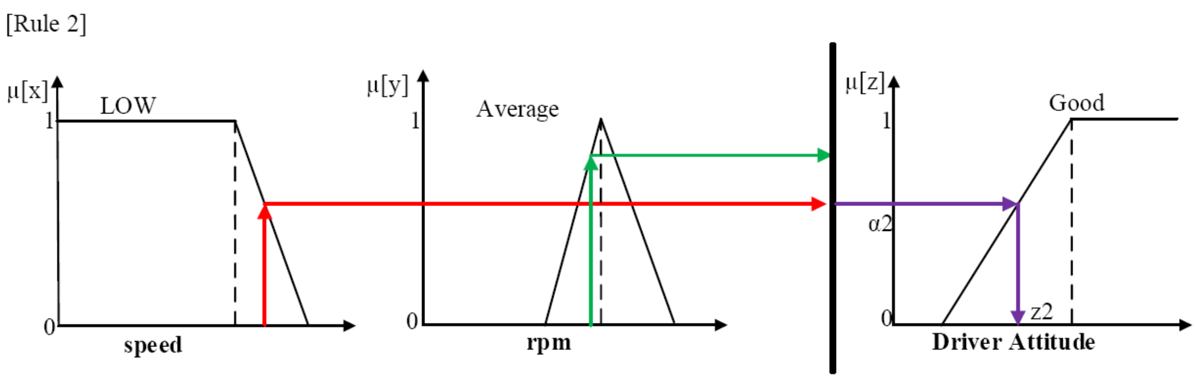

FIGURE 3. Implication of rule 2

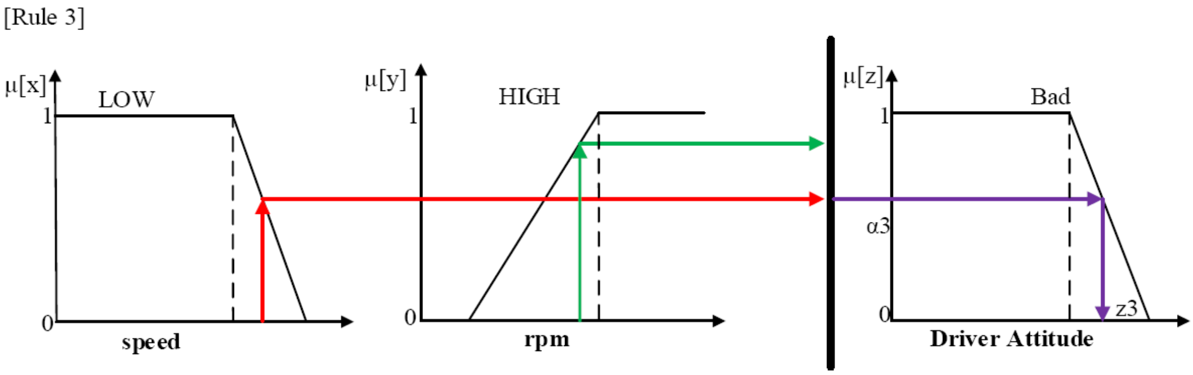

FIGURE 4. Implication of rule 3

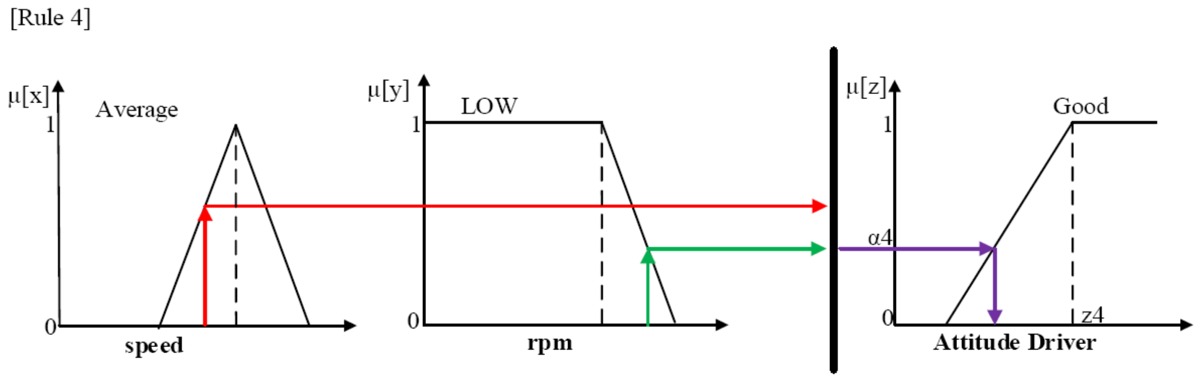

FIGURE 5. Implication of rule 4

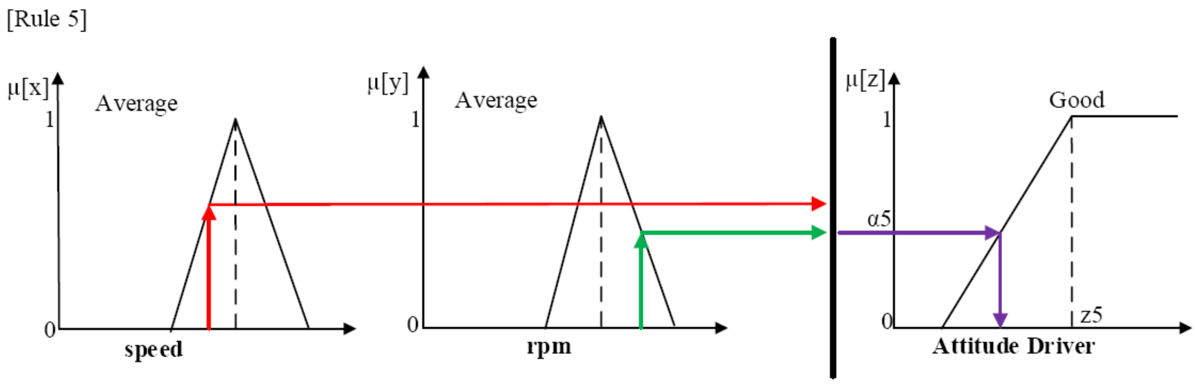

FIGURE 6. Implication of rule 5

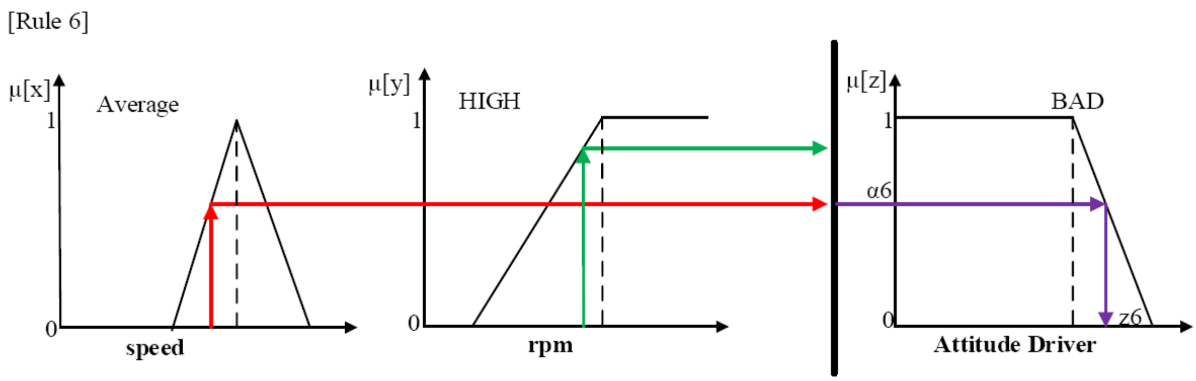

FIGURE 7. Implication of rule 6

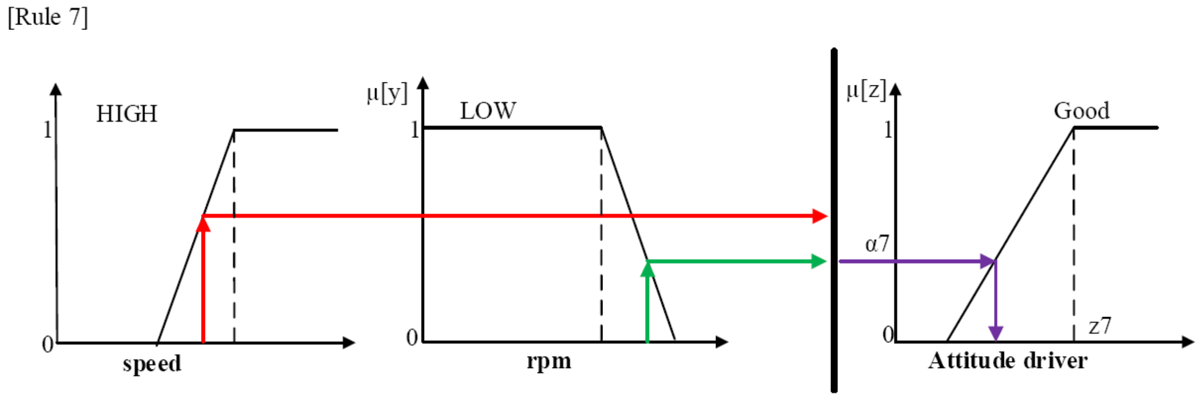

FIGURE 8. Implication of rule 7

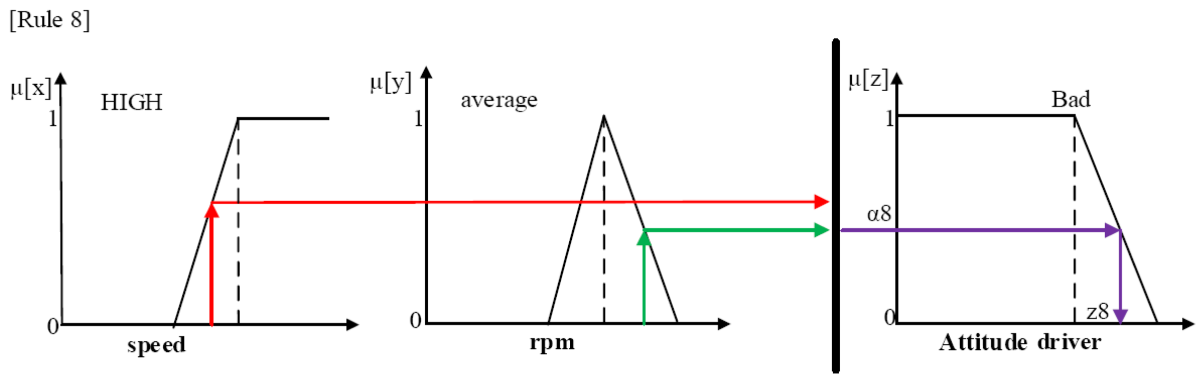

FIGURE 9. Implication of rule 8

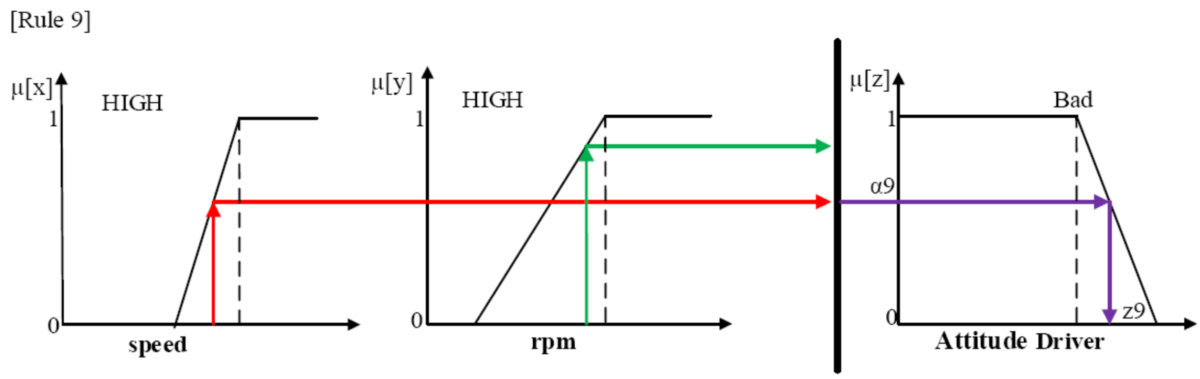

FIGURE 10. Implication of rule 9

limits for each input and output value based on the attitude determination process and the implications of the fuzzy rules.

The functions have some gaps when the output values are above 70 because of the optimum values of the rules; medium speed and rpm values will give the output values of good driver attitude.

The next step is the defuzzification, which refers to finding one single crisp value that summarizes the fuzzy set. Here, the calculation uses the center average defuzzifier Equation (19) where the value of α_n is the sum of all values of fuzzy rules in the system, while z_n is the sum of all the implications of the output values of the fuzzy rules in the system.

$$z = \frac{\sum(\alpha_n \times z_n)}{\sum(\alpha_n)} \tag{19}$$

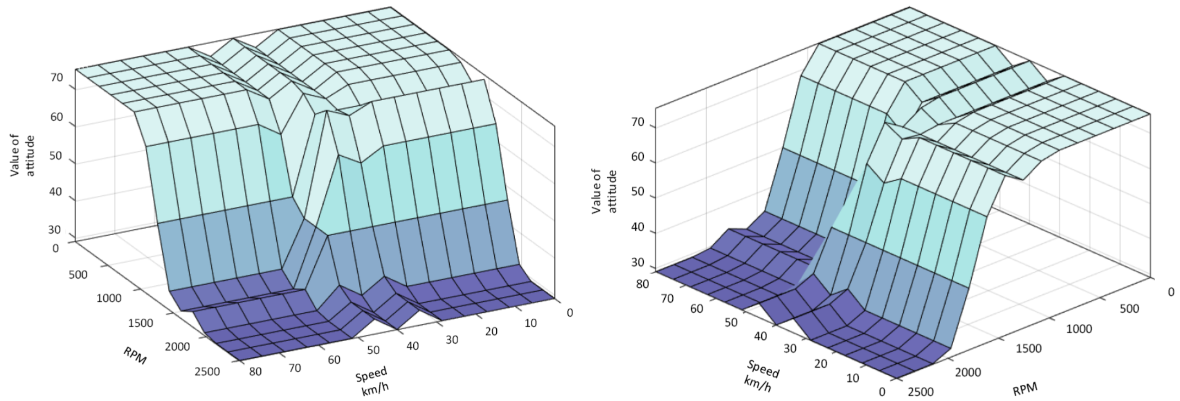

FIGURE 11. The relation between the input (speed and rpm) and output (attitude of the driver) based on the Tsukamoto fuzzy model

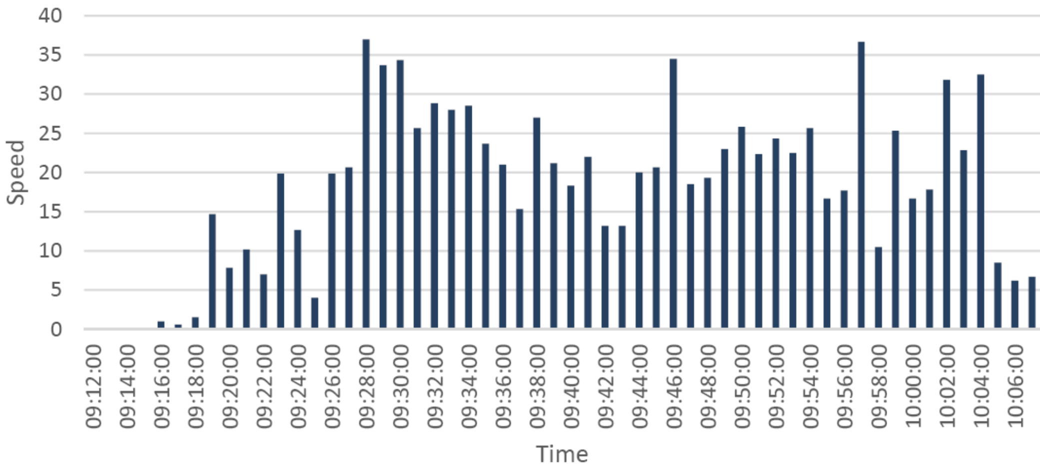

FIGURE 12. Speed values in this test scenario

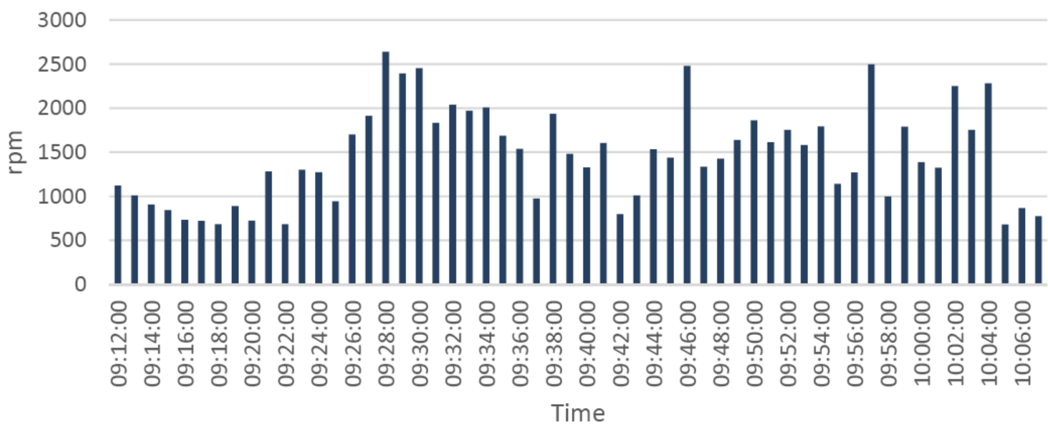

FIGURE 13. Rpm values in this test scenario

3. **Field Test.** The system design was tested using the Toyota Yaris 2015 model on a 16.93 km track between the campus of Institut Teknologi Bandung in the city center of Bandung and Lembang in western Bandung in a 55 minutes test. Figures 12 and 13 respectively show the graphs of the speed and rpm of the car during the test.

The trip provided 333 data samples. Based on those data, the percentages of good and bad driver attitude and the z values for every sample were defined and shown in Figures

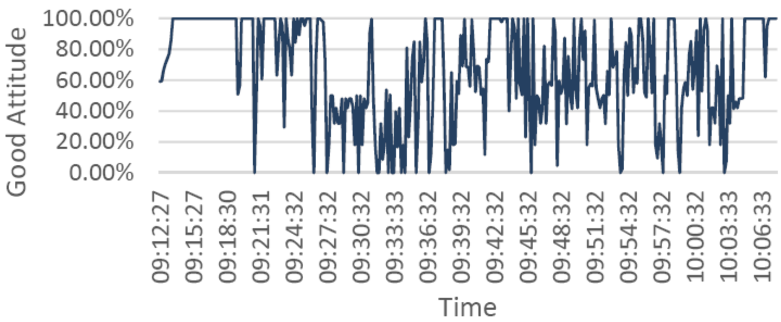

FIGURE 14. Good driver attitude for every sample for this test scenario

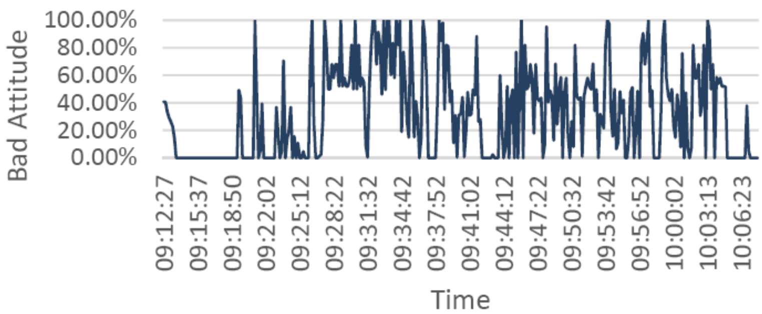

FIGURE 15. Bad driver attitude for every sample for this test scenario

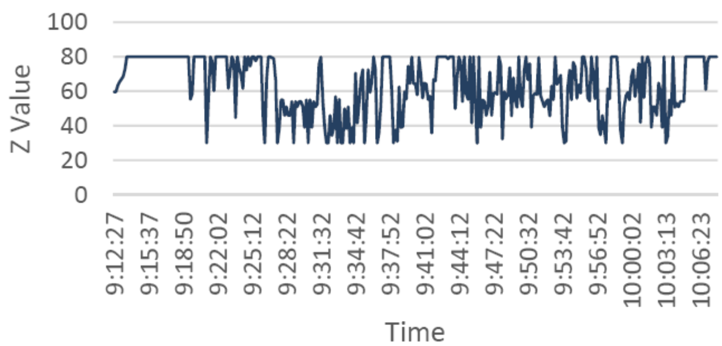

FIGURE 16. z value for every sample for this test scenario

14 to 16. The average percentage of good driver attitude was 66.88% and the average percentage of bad driver attitude was 33.12%.

Alternatively, the data was processed to calculate the percentages of good and bad driver attitude and the z values per minute. The average percentage of good driver attitude was 65.93% and the average percentage of bad driver attitude was 34.07%. This was the lowest average percentage of good driver attitude.

Taking the average values of good and bad driver attitude from the average z value per minute gives an average percentage of good driver attitude of 66.96% and an average percentage of bad driver attitude of 33.04%. This is the highest average percentage of good driver attitude.

4. **Conclusions.** This paper describes the implementation of a monitoring system of the attitude of car drivers using the Tsukamoto fuzzy model. The driver attitude could be determined using the cars' speed and rpm data based on road rules and regulations in Indonesia. The driver attitude was presented by the average percentages of good and bad

driving behavior. This system can be applied on public transport vehicles such as taxis and for car rental services.

This method is implemented using an OBD-II module, which interfaces the car's engine to a smartphone. The smartphone sends the car's data to the server via mobile Internet. This system has been tested on the road in Bandung, Indonesia. During this test, the average percentages of good and bad driving attitude were found using calculations per sample, per minute or by the average value of z. The test shows that the average percentage of good driver attitude taken from the average value of z gives the highest average percentage of good driver attitude. Meanwhile, the average percentage of good driver attitude calculated per minute gives the lowest value.

REFERENCES

[1] E. Husni, G. Boy et al., Applied Internet of Things (IoT): Car monitoring system using IBM BlueMix, *Proc. of International Seminar on Intelligent Technology and Its Application*, pp.417-422, 2016.

[2] J. E. Meseguer, C. K. Toh, C. T. Calafate, J. C. Cano and P. Manzoni, Drivingstyles: A mobile platform for driving styles and fuel consumption characterization, *Journal of Communications and Networks*, vol.19, no.2, pp.162-168, 2017.

[3] M. Zhang, C. Chen, T. Wo, T. Xie, M. Z. A. Bhuiyan and X. Lin, SafeDrive: Online driving anomaly detection from large-scale vehicle data, *IEEE Trans. Industrial Informatics*, vol.13, no.4, pp.2087-2096, 2017.

[4] M. U. H. Rasyid, E. M. Kusumaningtyas and F. Setiawan, Application to determine water volume for agriculture based on temperature & humidity using wireless sensor network, *Proc. of International Conference on Knowledge Creation and Intelligent Computing*, pp.105-112, 2016.

[5] S.-P. Wan and D.-F. Li, Atanassov's intuitionistic fuzzy programming method for heterogeneous multiattribute group decision making with Atanassov's intuitionistic fuzzy truth degrees, *IEEE Trans. Fuzzy Systems*, vol.22, no.2, pp.300-312, 2014.

[6] L. Atanassova, A new intuitionistic fuzzy implication, *Cybernetics and Information Technologies*, vol.9, no.2, pp.21-25, 2009.

[7] K. Atanassov, On eight new intuitionistic fuzzy implications, *Proc. of the 3rd International IEEE Conference on Intelligent Systems*, London, UK, pp.4-6, 2006.

[8] C. Cornelis, G. Deschrijver and E. E. Kerre, Classification of intuitionistic fuzzy implicators: An algebraic approach, *Proc. of the 6th Joint Conference on Information Sciences*, pp.105-108, 2002.

[9] R. A. Aliev, W. Pedrycz, O. H. Huseynov and S. Z. Eyupoglu, Approximate reasoning on a basis of Z-number-valued If-Then rules, *IEEE Trans. Fuzzy Systems*, vol.25, no.6, pp.1589-1600, 2017.

[10] Z. Wang, J. M. Gao, R. X. Wang, K. Chen, Z. Y. Gao and W. Zheng, Failure mode and effects analysis by using the house of reliability-based rough VIKOR approach, *IEEE Trans. Reliability*, vol.67, no.1, pp.230-248, 2018.

[11] J. Lorkowski, V. Kreinovich and R. Aliev, Towards decision making under interval, set-valued, fuzzy, and Z-number uncertainty: A fair price approach, *Proc. of IEEE International Conference on Fuzzy Systems*, pp.2244-2253, 2014.

[12] J. M. Mendel, Fuzzy logic systems for engineering: A tutorial, *Proc. of the IEEE*, vol.83, no.3, pp.345-377, 1995.